



2016 CAPACITY BUILDING

NASA Earth Science
Applied Sciences Program

2016 Capacity Building Calendar Year Summary

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I. Introduction

The Earth Science Division's (ESD) Applied Sciences Program (ASP) promotes efforts to discover and demonstrate innovative and practical applications of Earth observations. ASP activities partner with organizations from the public and private sectors to apply scientific findings and satellite data in their decision-making activities. The Program has three primary lines of business: Applications, Capacity Building, and Mission Planning. All Program activities support goals to deliver near-term uses of Earth observations, build capabilities to apply Earth science data, and contribute to satellite mission planning.

The Applied Sciences' Capacity Building Program (CBP) builds capacity within the United States and the developing world to expand the Earth observations user base, and increase the awareness within non-traditional audiences of NASA Earth observations data and products. CBP engages across the ASP Application Areas portfolios of Water Resources, Disasters, Ecological Forecasting, and Health & Air Quality, as well as other application areas including Agriculture, Climate, Energy, Oceans, and Weather.

The Capacity Building Program works through both program and element activities. Program activities include participating in both domestic and international capacity building groups, such as the Group on Earth Observations (GEO), the Committee on Earth Observation Satellites (CEOS), and the Coordinating Group for Meteorological Satellites (CGMS), as well as identifying partnership opportunities to reach new end-users. The program supports three Elements, including Applied Remote Sensing Training (ARSET), DEVELOP, and SERVIR, along with an initiative focused on building capacity to use Earth observations of indigenous peoples in North America.

Element Descriptions

ARSET empowers the global community through remote sensing trainings. Through online and in-person trainings, participants learn how to use NASA Earth data, applications, and models. Participants can then apply these free resources to environmental management and decision support. Trainings are intended for policymakers, non-governmental organizations (NGOs), and other applied science professionals. To access the training materials, join the listserv, and learn about upcoming activities, please visit <http://arset.gsfc.nasa.gov/>.

DEVELOP addresses environmental and public policy issues by conducting interdisciplinary feasibility projects that apply the lens of NASA Earth observations to community concerns around the globe. Bridging the gap between NASA Earth Science and society, DEVELOP provides workforce development opportunities for both participants and partner organizations to better prepare them to address the challenges that face our society and future generations. With the competitive nature and growing societal role of science and technology in today's global workplace, DEVELOP is fostering an adept corps of tomorrow's applied scientists and leaders. To learn more about DEVELOP, view previous projects, and propose a project idea, please visit <http://develop.larc.nasa.gov/>.

SERVIR, a joint development initiative of NASA and USAID, works in partnership with leading regional organizations around the globe to help developing countries use information provided by Earth observing satellites and geospatial technologies for managing climate risks and land use. SERVIR empowers decision makers with tools, products, and services to improve awareness and increase access to geospatial data in Eastern & Southern Africa, West Africa, Hindu Kush-

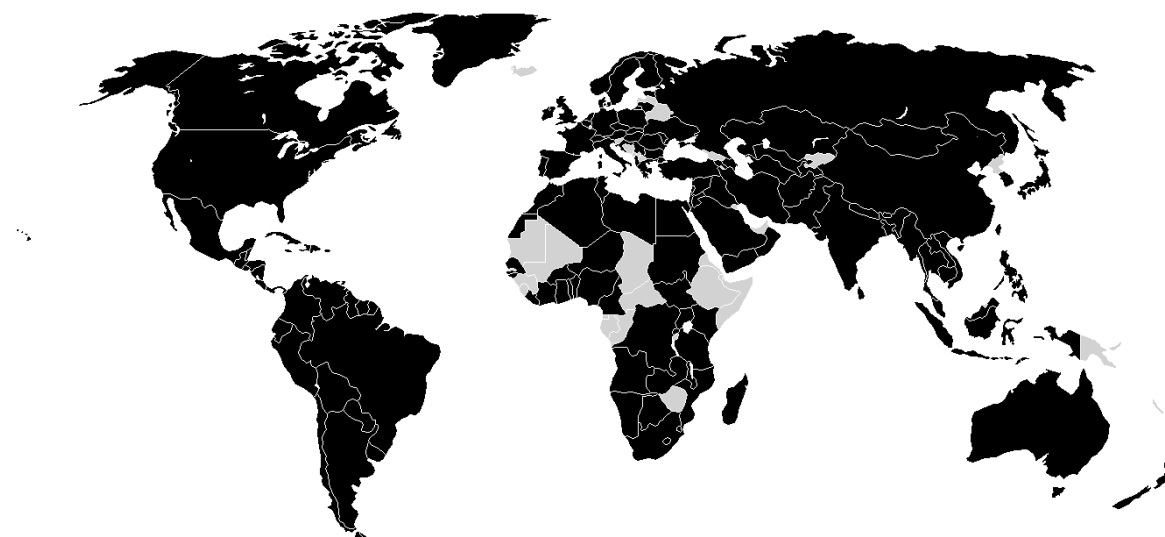
Himalaya, and Lower Mekong. For more information about SERVIR and its network of regional hubs, visit www.servirglobal.net/.

II. 2016 Overview

Throughout 2016, the Capacity Building Program continued to refine and strengthen its many contributions to the Agency. CBP achieved the following impacts "by the numbers" in 2016:

4,259: Individuals Engaged	8: Application Areas Addressed
1,684: Organizations Engaged	50: U.S. States Impacted
55: Trainings Given	9: U.S. Territories & Holdings Impacted
77: Feasibility Studies Conducted	142: Countries Impacted
35: Multi-year Projects Conducted	23: Publications
65: Earth Observation Assets Applied	103: Conferences & Meetings Attended

The Capacity Building Program's global impact can also be shown "by the map" for 2016:



Black denotes the 142 countries impacted by CBP; gray denotes the 53 not impacted

Read on to learn more about CBP's accomplishments and highlights.

III. Accomplishments & Highlights

Programmatic Accomplishments

Throughout 2016, the program continued to address the CBP strategic goals to expand the networks of individuals and institutions to be aware of, able to access, and able to use Earth observations.

New additions included a SERVIR hub in West Africa, a DEVELOP node in Tempe, Arizona, more application area training topics offered by ARSET, and a completed study of needs of North American indigenous peoples for Earth observations and how those needs are currently being addressed. Key indicator tracking by the three CBP Elements was strengthened through organizational and reporting system improvements to further the depth and quality of projects,

partnerships, and trainings. CBP indicators show that the program's geographic reach continued to grow with impact in all 50 U.S. states and nine U.S. territories, and a global impact across 142 countries, where reach is mapped by including project study areas and locations of end-users and individuals engaged in CBP activities. The Capacity Building Program engaged 4,259 individuals and 1,684 organizations through 55 trainings, 77 feasibility studies, and 35 multi-year projects. The number of individuals and institutions engaged set new records with a total of 4,259 individuals (an increase of 155 from 2015) and 1,684 institutions (an increase of 315). Overall, CBP participated in a total of 103 conferences and meetings – 74 science and policy conferences and 29 NASA meetings – and published 23 articles and features in 2016, both increases from 2016.

Collectively, the program utilized 65 Earth-observation assets in trainings and projects (Appendix C), furthering the goal to enable sustained use of existing NASA Earth observations and the ability to incorporate new observations and applications as they become available, e.g. the use of HICO in the new ARSET coastal monitoring training. SERVIR's selection of 16 new Applied Science Team members will contribute to this goal over the next three years by bringing in innovative applied science to meet end user decision needs sustainably across the SERVIR network.

ARSET contributed significantly to the CBP goal to build Earth sciences community capacity to define end-user needs, collect and share robust feedback, build capacity, and assess impact of capacity building activities through their new webinar series on training best practices. SERVIR has been developing a service planning framework that includes iterative end-user needs definition and co-development of applications to build capacity, with ways to assess impact included as well. As a contribution to CEOS WGCapD, CBP team members led a session and synthesized training best practices of WGCapD member agencies.

To improve feedback of lessons learned through capacity building to the broader Earth science community, CBP continued to grow a community of practice of Earth observation use capacity building practitioners through a focused session and lunch at the American Geophysical Union fall meeting. CBP also shared lessons informally at the Applied Science Program's Associate meeting. CBP continues to participate in NASA Earth Science Division mission Science Teams to hear the latest results and provide feedback from capacity building activities.

Program elements had a strong year in 2016. Accomplishments and highlights are summarized below.

ARSET had a record breaking year having conducted the most trainings (15), trained the most individuals (3,277), engaged the highest number of organizations (1,392), and impacted the most countries (130). The program set a record for most participants trained in one day on June 9th, 2016 when it had 1,023 people engaged in its trainings, and hosted the largest webinar in its history when 768 attendees attended the "Applications of Remote Sensing to Soil Moisture & Evapotranspiration". ARSET also expanded its offering of trainings into new thematic areas such as oceans & coastal management, carbon monitoring, NDVI time series, and training best practices.

DEVELOP had a dynamic year engaging 359 participants and 125 partner organizations through 77 projects that took place at 13 nodes and impacted 42 U.S. states and 55 countries (44 through project study areas and 19 by means of individuals participating in the program). DEVELOP expanded its reach in the southwestern U.S. with the addition of a node in Tempe, Arizona, in collaboration with the Maricopa County Department of Public Health and Arizona State University. In support of the National Park Service (NPS) Centennial in 2016, DEVELOP

partnered with NPS on a campaign of 17 projects that explored the use of NASA Earth observations to enhance monitoring and decision making in national parks and monuments across 25 states. The program presented project results and participated in 59 science and policy conferences and meetings, co-chaired a session at the AGU Fall Meeting, and served as a key note speaker at two conferences. The program also continued its video series highlighting the use of Earth observations in decision making, with a record 32,509 YouTube views in 2016. Four DEVELOPErs and two DEVELOP project teams were recognized for their outstanding work through multiple awards including AGU's Data Visualization Storytelling Contest, NASA's Silver Achievement Medal, and NOAA NCEI Employees' Choice Award for Innovative Product.

In 2016, SERVIR was active in 40 countries, with four regional hubs located at the Regional Center for Mapping of Resources for Development (RCMRD) in Nairobi, Kenya, the International Centre for Integrated Mountain Development (ICIMOD) in Kathmandu, Nepal, the Asian Disaster Preparedness Center in Bangkok, Thailand, and through a collaboration of Agriculture, Hydrology and Meteorology Regional Center (AGRHYMET), the Comité permanent Inter-Etats de Lutte contre la Sécheresse dans le Sahel (CILSS), Tetra Tech Incorporated and multiple consortia members in Niamey, Niger. The program conducted 35 projects and 39 trainings in 2016. In 2016, SERVIR developed, provided oversight for, enhanced, or launched, 23 applications and tools, including geoportals to improve data availability and sharing, online agricultural atlases to support food security, and vulnerability assessment tools to inform disaster-related decisions. These products and tools operate based on data from 21 different satellite instruments. A total of 623 people were trained in the use of SERVIR tools, technologies, data, and methodologies, with a total of 298 institutions engaged. With SERVIR's help, an estimated 122 institutions saw improvements in their capacity to address issues relating to changing climates.

Highlight Events & Activities

The Capacity Building Program's activities are best illustrated by highlighting events and activities that brought Earth observations to decision makers. The following are some of the top highlights for 2016:

In September, ARSET provided a five-week webinar series on access and applications of soil moisture and evapotranspiration data products. There were 768 attendees from 479 organizations and 81 countries. The high demand and participation broke all previous ARSET records, and accounted for nearly a quarter of the individuals trained in 2016. Survey responses from the attendees who completed the survey (about 30 percent) indicate the training was highly successful.



ARSET initiated a collaboration with the Indian Space Agency (ISRO) and the Indian Institute of Remote Sensing (IIRS). The group held discussions on future joint training activities and exchange of capacity building best practices. ARSET also received an invitation from the U.S. Department of State to tour four Indian cities and participate in panel discussions on air quality challenges in India and the role of remote sensing, providing high visibility for NASA and ARSET. In 2017, ARSET and ISRO will collaborate on a training and continue working together.



In celebration of the National Park Service (NPS) Centennial, DEVELOP conducted 17 projects over the course of the year that focused on monitoring change and threats to America's national parks and highlighting the use of Earth observations to support our national treasures. These projects spanned multiple NPS regions across 25 states and partnered with parks, monuments, and inventory and monitoring networks to support the integration of NASA Earth observations in decision making thorough the park system.

DEVELOP published two peer-reviewed articles, one each in the *Bulletin of American Meteorological Society* and AGU's *Eos*, two programmatic articles on *Earthzine* and the LP DAAC website, and two project overviews in *The Earth Observer*. The program's people and projects were featured in 18 articles in venues ranging from local media, university newspapers, AGU's Thriving Earth Exchange, and NASA's *Earth Observatory* and social media postings.

DEVELOP's people and projects were recognized through a series of awards including its Pacific Water Resources project winning the NOAA NCEI Employee's Choice Award for Innovative Product, DEVELOP's Karen Allsbrook receiving NASA's Silver Achievement Medal for her many contributions to the Agency's mission, DEVELOP's Allison Daniel and Dr. Sara Lubkin winning two of five grand prizes of AGU's 2016 Data Visualization Storytelling Contest, and the Chaco Canyon Cross-Cutting project won 1st place in the Physical & Liberal Sciences category of the Wernher von Braun Memorial Symposium's student competition.



Through the NASA ROSES peer review process, 16 proposed projects were selected for the new SERVIR 2016 AST. Targeted toward a balanced portfolio in water and water-related disasters, food security and agriculture, weather and climate, and land use and ecosystems, the projects will meet needs identified by the four regional SERVIR hubs in Eastern and Southern Africa, West Africa, Hindu Kush-Himalaya (HKH), and the Lower

Mekong region of Southeast Asia. Each project was developed in collaboration with a regional SERVIR hub based on the needs identified for that region.

SERVIR launched its newest hub – SERVIR-West Africa – on July 14th 2016. This hub is implemented by the Agriculture, Hydrology and Meteorology Regional Center (AGRHYMET), a specialized agency of the Comité permanent Inter-Etats de Lutte contre la Sécheresse dans le Sahel (CILSS) (the Permanent Inter-State Committee against Drought in the Sahel), headquartered in Niamey, Niger; Tetra Tech Incorporated, headquartered in Pasadena, California; and a consortium of partners serving the West Africa region. The hub will serve Ghana, Burkina Faso, Senegal, and Niger, helping policy makers and other officials make more



informed decisions in four areas: food security and agriculture; water and disasters; weather and climate; and land use, coastal zones, and forest management.

SERVIR developed a tool in 2016 called ClimateSERV. Using ClimateSERV, development practitioners, scientists/researchers, and government decision-makers can readily analyze historical rainfall for the past 30 years and compare it with the best available forecasts for the next 180 days for their defined area of interest to improve understanding of, and make improved decisions for, issues related to agriculture and water availability. ClimateSERV can help those decision-makers assess and monitor large-scale rainfall patterns, analyze how those patterns may have changed over time, determine likelihood of drought, and infer crop condition.

During 2016, a SERVIR AST project led by Amy Thomas of Battelle successfully completed their planned activities. This project developed a satellite-derived high resolution regional aerosol products and visualization system for national air quality modeling systems for the Ministry of Environment and Natural Resources El Salvador and Costa Rica. The project team worked with El Salvador MARN to develop a visualization system for the MODIS-based Aerosol Optical Depth product. The system, installed on MARN computers, is being upgraded by MARN for broader use. The project team also gave several training sessions on use of the satellite data and air quality modeling system to create actionable information. In Costa Rica, the project team worked with the National Meteorological Institute (IMN) to understand the needs of the agency and designed a blend of modeling and satellite-derived products. The result was development of a finely tuned CMAQ model. The project team trained IMN staff members, who are now confident in use of the tools in their operations.

Another successfully completed AST project was led by Dalia Kirschbaum (GSFC). This project developed a Central American landslide hazard forecasting system (LHASA) using satellite data to assess regional landslide hazards. The system provides probabilistic landslide assessments for real-time and forecasted landslide activity. It has been transferred to CentroClima, a regional portal for environmental data. The project team also trained MARN colleagues on use of this system. The project truly engaged the stakeholders during the development process, and provided significant training on it. Even though this project lacked a formal SERVIR engagement in the region, it made significant progress through collaborations with end users. The SERVIR Science Coordination Office has developed infrastructure cloud based solutions to continue providing technical support from NASA Marshall Space Flight Center in Huntsville. The project team has made significant progress in providing similar capabilities in Nepal, where the SERVIR hub is actively engaged in uptake of the methodology.

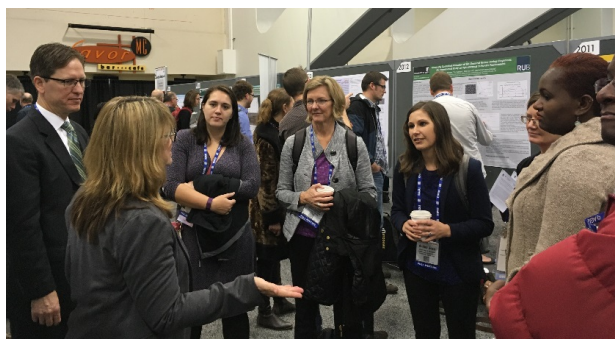
Cindy Schmidt led an effort to better understand the needs and data gaps in the use of geospatial data within Indigenous communities in North America. Indigenous peoples in North America are place-based and depend on natural resources to sustain their economies and cultural and spiritual practices. The study was completed in 2016 and summarizes: 1) How federal agencies are currently working with Indigenous communities; 2) What NASA is currently doing with indigenous communities; 3) The key natural resource management needs of indigenous communities and 4) The extent that indigenous communities are currently using remote sensing/geospatial technology. This study will inform plans for 2017.

IV. Community Engagement

Community Leadership

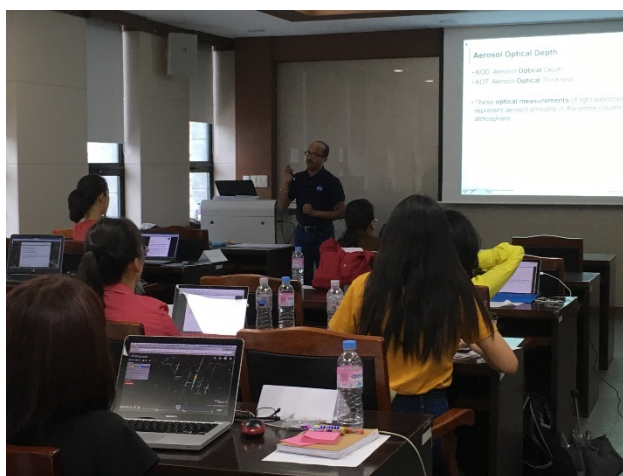
In 2016, Capacity Building participated, presented and led sessions in national conferences, interagency and international events. The CBP Program Manager, Dr. Nancy Searby, provides

leadership in the interagency U.S. Group on Earth Observations (USGEO)'s International Activities Working Group, and co-leads the U.S.'s participation in the regional initiative called AmeriGEOSS. She is a member of the GEO Capacity Building Coordination Working Group and the CEOS Working Group for Capacity Building and Data Democracy (WGCapD). Highlights of these broader activities include AmeriGEOSS Week in Bogota, Colombia, in June 2016 and the 5th annual WGCapD meeting in Hampton Roads, Va., in March 2016.



meeting was the establishment of a periodic newsletter to bolster communication of the community of practice and distribute news and best practices.

ARSET hosted five in-person training workshops in conjunction with conferences to leverage attendance and enhance Earth observation skill development. These workshops included a water quality monitoring workshop at the National Water Quality Monitoring Conference, May 5, in Tampa, Fla., an air quality monitoring workshop August 28-29, as a pre-conference event for the 17th IUAPPA World Clean Air Congress and 9th Clean Air Asia Better Air Quality Conference, a conservation management workshop at the IUCN World Conservation Congress in Honolulu, Hawaii, on September 4, an air quality workshop ahead of the Atmospheric Optics: Aerosols, Visibility, and the Radiative Balance Conference in Jackson Hole, Wyo., September 26, and another air quality monitoring training on November 14 at the 2nd International Smoke Symposium in Long Beach, Calif.



DEVELOP joined and led the science and policy communities in a variety of activities in 2016. The program co-chaired a session at the AGU Fall Meeting, DEVELOPers gave two key note speeches at conferences focused on Great Lakes water management in Niagara Falls, N.Y., and another focused on gender and GIS inclusion in disaster response and resilience in Bangkok, Thailand. The program engaged policy makers through informative visits to Congress in August and participated in two Aerospace Days in Virginia and Idaho. In celebration of the National Park Service Centennial, DEVELOP led NASA's engagement with the NPS by conducting 17 projects that focused on the use of Earth observations to support management of the nation's national parks and monuments. DEVELOP also began engagement with AGU's Thriving Earth Exchange to explore how NASA and AGU could support local communities with their decision making.

In 2016, SERVIR's Science Coordination Office (SCO) pursued increased collaboration with regional initiatives such as the Working Group on Land Cover for Africa and AfriGEOSS by co-chairing its Working Group and serving as the chair of its technical meetings. SERVIR's NASA Program Manager, Dan Irwin, gave the distinguished 2016 Schermerhorn Lecture at the Opening of the Academic Year 2016-2017 of the University of Twente in Enschede, Netherlands, as well as attended and presented at the 22nd Conference of the Parties (COP 22) to the UN Framework Convention on Climate Change (UNFCCC) in Marrakech, Morocco. An RCMRD hub team member participated as a trainer in an SRTM workshop organized by CEOS in Kathmandu, Nepal. SERVIR also engaged with the International Institute for Geo-Information Science and Earth Observation, originally known as ITC, to explore potential avenues of cooperation.

Enhancing Data Accessibility

To increase the capabilities of individuals and institutions to use and apply NASA Earth observations, CBP has continued efforts to improve data discovery, access, and management.

ARSET has built skills to acquire and use Earth observations for decision support. In 2016, ARSET demonstrated or presented 99 instruments, missions, and web tools (see Appendix). Through these capacity building activities, ARSET facilitated access to satellite data hosted by NASA and other organizations, including NOAA, USDA, USFS, private sector, and nonprofits. The program is deeply engaged with multiple NASA data centers, serving as a formal member of six of the user working groups (ASDC, GES DISC, LAADS DAAC, LANCE, LP DAAC, and ORNL DAAC) in order to share the perspectives and needs of the end-user community with the data centers.

DEVELOP continued efforts to expand access to tools and results created by its feasibility projects through its publicly available GitHub portal of data processing tools. In 2016, the program had NASA's Software Release Authority approve the release of four tools for public dissemination including: Surface Aquatic Vegetation Detection Tool (SAVDT) that generates shapefiles from recently acquired satellite data where water hyacinth is most likely present, Land Surface Temperature MODIS Visualization (LaSTMov) that creates heat vulnerability maps using satellite data, Detecting Realtime Increased Precipitation / Sudden Landslide Identification Product (DRIP-SLIP) that identifies landslides and extreme precipitation monitoring software, and the Drought Severity Assessment Tool (DSAT) that calculates periodical Standardized Precipitation Index (SPI) values cell by cell from monthly precipitation rasters. DEVELOP also used Google Earth Engine in 13 projects to harness cloud computing for running analyses, simplification of processing for project partners, and increase utility of DEVELOP products.

The SERVIR SCO prepared 36 time-series datasets produced by AST members, extracted from the Distributed Active Archive Centers (DAACs) or generated through modeling processes, for inclusion in decision support systems such as ClimateSERV and the SERVIR Global Data Catalog, enabling broader and more user-friendly utilization in different scenarios. These datasets contain valuable observed and forecast information about rainfall, soil moisture, runoff, Normalized Difference Vegetation Index (NDVI), and more. The geographical extents of these datasets vary from global to specific regions (e.g., watersheds in the lower HKH).

V. 2016 CBP Portfolio

The Capacity Building Program engages in two types of activities within its portfolio: projects and trainings. In 2016, the program conducted 106 projects (77 feasibility studies, 35 multi-year projects) and 55 trainings (10 online, 45 in-person). CBP activities covered a broad range of themes in alignment with eight of the Applied Sciences' Application Areas: Agriculture, Climate, Disasters, Ecological Forecasting, Health & Air Quality, Oceans, Water Resources, and Weather.

More information about individual projects and trainings can be found on ARSET, DEVELOP, and SERVIR websites.

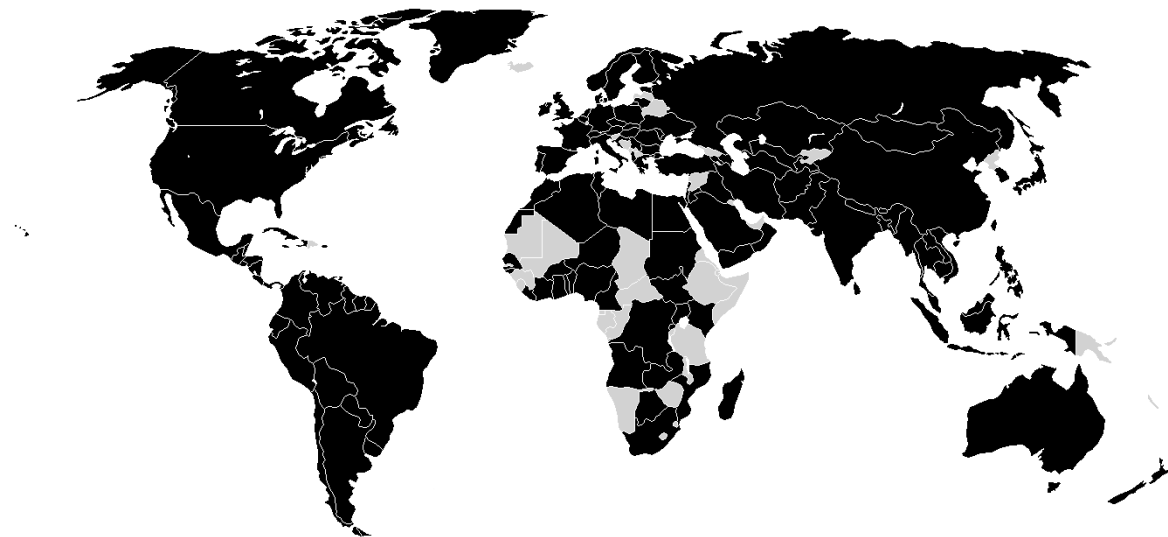
Application Area	Projects	Trainings	Portfolio %
Agriculture	18 (9 Feasibility / 9 Multi-Year)	1 (1 Online / 0 In-Person)	11%
Climate	14 (7 Feasibility / 7 Multi-Year)	8 (0 Online / 8 In-Person)	13%
Disasters	9 (6 Feasibility / 3 Multi-Year)	7 (2 Online / 5 In-Person)	10%
Eco Forecasting	26 (20 Feasibility / 6 Multi-Year)	15 (3 Online / 12 In-Person)	24%
Health & AQ	10 (8 Feasibility / 2 Multi-Year)	8 (2 Online / 6 In-Person)	11%
Oceans	3 (3 Feasibility / 0 Multi-Year)	0 (0 Online / 0 In-Person)	2%
Water Resources	26 (19 Feasibility / 7 Multi-Year)	9 (1 Online / 8 In-Person)	21%
Weather	2 (1 Feasibility / 1 Multi-Year)	1 (0 Online / 1 In-Person)	2%
Cross-Cutting	4 (4 Feasibility / 0 Multi-Year)	6 (1 Online / 5 In-Person)	6%

VI. Geographic Reach

Geographic Coverage of Activities

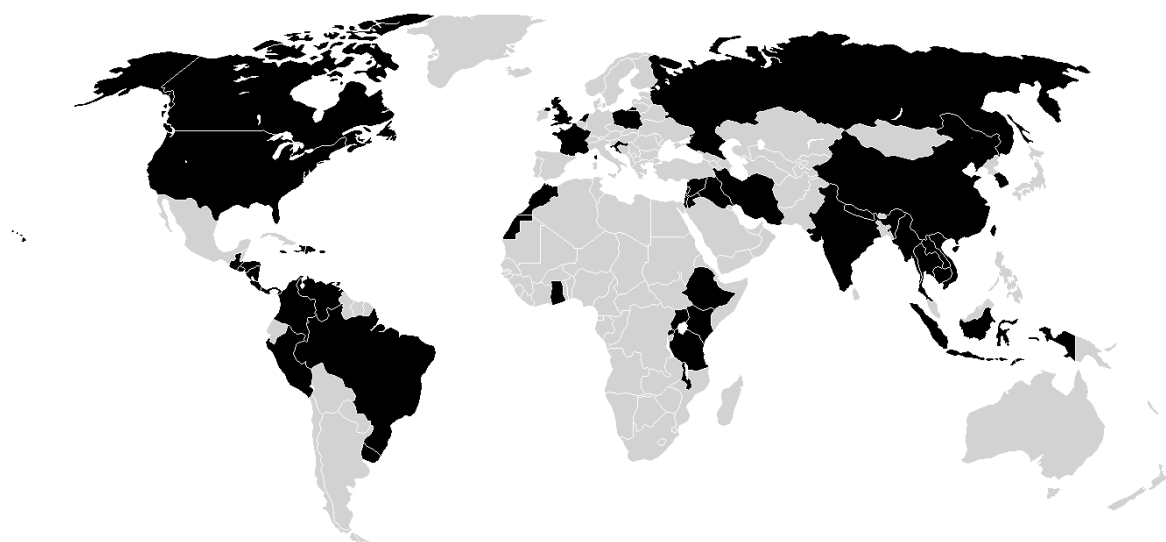
The Capacity Building Program actively participated in U.S. and international Earth observations and capacity-building activities in 2016 through USGEO, GEO, CEOS, and program element activities.

ARSET online and in-person trainings reached individuals in 130 countries, an increase from 2015 (128 countries impacted). In 2016, training attendees were comprised of 35 percent U.S. and 65 percent international, consistent with 2015 totals.



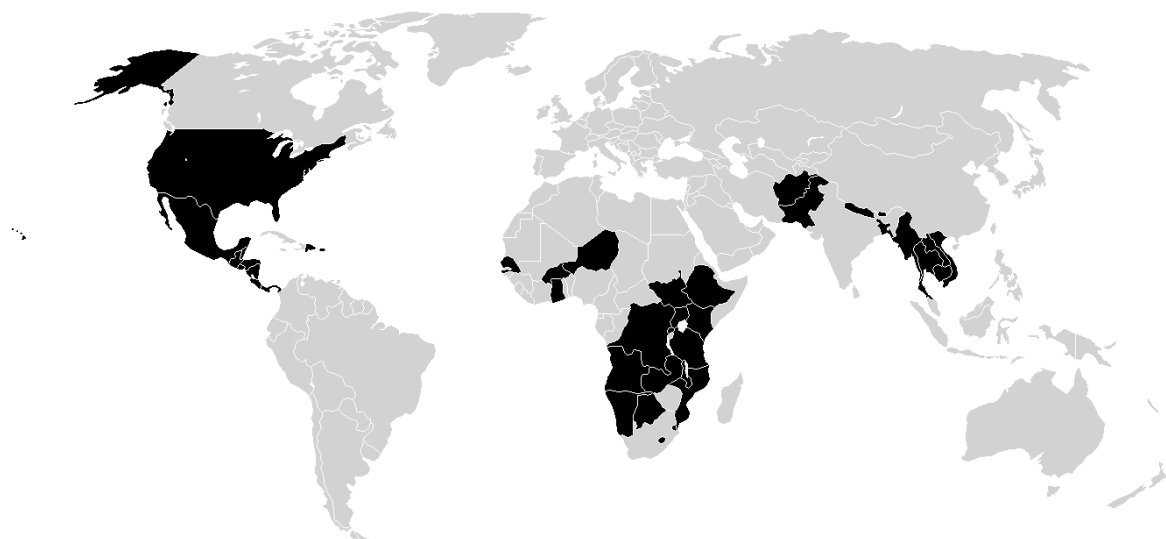
Black denotes the 130 countries impacted by ARSET

DEVELOP's primary focus is domestic capacity building and in 2016, the project portfolio consisted of 73 percent of projects addressing issues in 42 U.S. states and 88 percent of participants were U.S. citizens from 37 states, with a total of 44 U.S. states impacted. The program virtually conducts a limited number of projects with international study areas and engages international participants already studying in the U.S. In 2016, and 27 percent international projects addressed issues in 44 countries and international participants from 19 countries were 12 percent of the individuals engaged on teams, with a total of 55 countries impacted.



Black denotes the 55 countries impacted by DEVELOP

SERVIR is inherently international, working in partnership with leading regional organizations around the globe to help developing countries use information provided by Earth observing satellites and geospatial technologies for managing climate risks and land use. SERVIR was able to directly engage 40 countries through the support of the regional hubs in 2016. Domestically, SERVIR's Science Coordination Office and Applied Sciences Team (AST) engaged 24 U.S. states and six countries in Mesoamerica.



Black denotes the 40 countries impacted by SERVIR

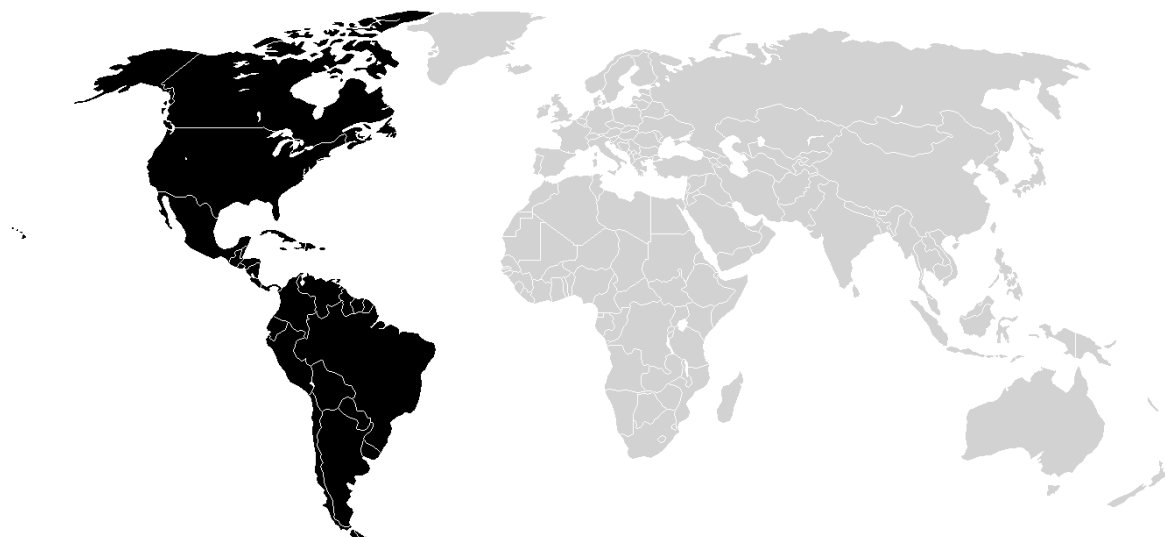
CBP organizes international activities by GEO Regional Caucus to assess progress and identify regions that have benefited most from the Program's capacity building.

Americas

CBP reached 35 countries in the Americas caucus region through:

- ▶ ARSET – 1,764 individuals through 5 in-person and 9 online trainings
- ▶ DEVELOP – 323 individuals through 65 feasibility studies and 1 in-person training

- ▶ SERVIR – 139 individuals and 3 multi-year projects and 1 online & 9 in-person trainings



Black denotes the 35 countries in the Americas impacted by CBP

More information for the multi-year projects:

Using Earth Observation Data to Improve REDD+ Policy in Mesoamerica and the Dominican Republic (ROSES 2011 - SERVIR AST)

Principal Investigator: Allen Blackman, Resources for the Future, Inc.

ASP Application Area: Ecological Forecasting

Thematic Service Area: Land Cover and Land Use Change and Ecosystems

Description: This project is improving the efficiency and effectiveness of REDD+ policy making in Mesoamerican countries. The project developed Web-based decision tools that use Landsat and MODIS data to characterize forest cover change and combine this information with geophysical, socioeconomic, and ecological characteristics, enabling end users to prioritize interventions in their regions. For example, this tool was used by the Inter-American Development Bank to prioritize locations in which to distribute eco-friendly cook stoves based on highest benefit from an environmental and economic perspective.

Applications of Satellite Products for Air Quality Monitoring, Analysis, Forecasting, and Visualization in the SERVIR Mesoamerica and Himalaya Regions (ROSES 2011 - SERVIR AST) [Mesoamerica & Himalaya Regions]

Principal Investigator: Amy Thomas, Battelle Memorial Institute

ASP Application Area: Health and Air Quality

Thematic Service Area: Weather and Climate

Description: This project, successfully completed in 2016, developed satellite-derived high resolution regional aerosol products and visualization system for national air quality modeling systems for MARN El Salvador and Costa Rica. The project team trained National Meteorological Institute (IMN) staff members, who are now confident in use of the tools in their operations.

Landslide Hazard Assessment and Forecasting System using Near Real-Time Remote Sensing Information over SERVIR-Mesoamerica (ROSES 2011 - SERVIR AST) [Mesoamerica & Himalaya Regions]

Principal Investigator: Dalia Kirschbaum, NASA Goddard Space Flight Center

ASP Application Area: Disasters

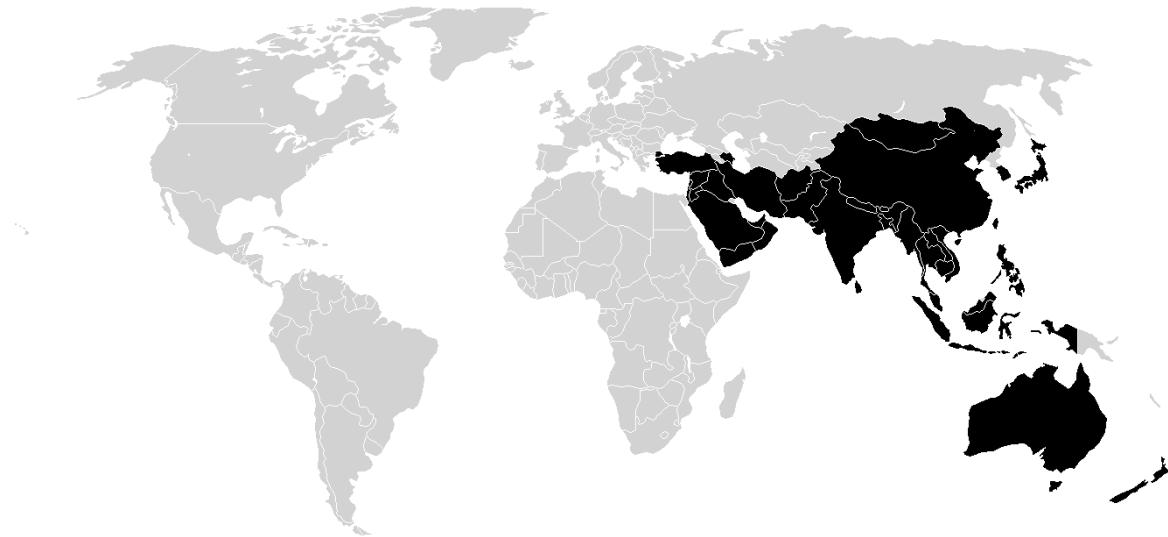
Thematic Service Area: Water Resources and Hydroclimatic Disasters

Description: This project, successfully completed in 2016, developed a Central American landslide hazard forecasting system (LHASA) using satellite data to assess regional landslide hazards. The system provides probabilistic landslide assessments for real-time and forecasted landslide activity. The system has also been piloted in Nepal and is providing very useful results there as well.

Asia and Oceania

CBP reached 37 countries in the Asia & Oceania caucus region through:

- ▶ ARSET – 811 individuals through 1 in-person and 9 online trainings
- ▶ DEVELOP – 27 individuals through 7 feasibility studies
- ▶ SERVIR – 263 individuals and 13 multi-year projects and 15 in-person trainings



Black denotes the 37 countries in Asia & Oceania impacted by CBP

More information for the multi-year projects:

Seasonal Prediction of HKH Hydrological Extremes with the South Asia Land Data Assimilation System (ROSES 2015 - SERVIR AST)

Principal Investigator: Benjamin Zaitchik, Johns Hopkins University

ASP Application Area: Climate

Thematic Service Area: Weather and Climate

Description: This project generates subseasonal to seasonal (S2S) hydrological forecasts for the Hindu Kush-Himalaya region, working with end-users to produce forecast products that describe the risk of drought or floods on time horizons of weeks to months.

Managing the Changing Water Resources South of the Himalayas (ROSES 2015 - SERVIR AST)

Principal Investigator: Cédric David, NASA Jet Propulsion Laboratory

ASP Application Area: Water Resources

Thematic Service Area: Water Resources and Hydroclimatic Disasters

Description: This project trains regional stakeholders and local water managers in the Hindu Kush-Himalaya Region to combine remotely sensed data from GRACE, MODIS, and AMSR2 with NASA modeling assets (GLDAS and RAPID) to provide actionable information on water resources and water-related disasters (floods and droughts), focusing on historical conditions and near real time estimates.

Comprehensive Stream Flow Prediction and Visualization to Support Integrated Water Management (ROSES 2015 - SERVIR AST)

Principal Investigator: Jim Nelson, Brigham Young University

ASP Application Area: Water Resources

Thematic Service Areas: Water Resources and Hydroclimatic Disasters

Description: This project develops a cloud-based water resources applications portal and specific web applications to empower the International Centre for Integrated Mountain Development to help water resource managers and other decision-makers in the Hindu Kush-Himalaya region access and use streamflow forecasts, flood mapping, and data. Access to these tools and information will enable them to prepare for and warn the public of impending floods and related disasters and promote resilience and recovery after flood events.

Monitoring Intense Thunderstorms in the Hindu Kush-Himalayan Region (ROSES 2015 - SERVIR AST)

Principal Investigator: Patrick Gatlin, NASA Marshall Space Flight Center

ASP Application Area: Weather

Thematic Service Area: Weather and Climate

Description: This project integrates NASA Earth Observing System information to facilitate daily assessments of the hazards posed by thunderstorms in the Hindu-Kush Himalayan region.

A Satellite-based Early Warning, Mapping and Post-Disaster Visualization System for Water Resources of Low-lying Deltas of the Hindu Kush-Himalayan Region (ROSES 2011 - SERVIR AST)

Principal Investigator: Faisal Hossain, University of Washington

ASP Application Area: Water Resources, Disasters

Thematic Service Area: Water Resources and Hydroclimatic Disasters

Description: This effort focused on developing modular satellite-based water resources and water hazard mapping, early warning and post-disaster assessment visualization system for use by stakeholders in the Ganges-Brahmaputra-Meghna and Indus River basins. The satellite altimetry based datasets are in routine use by the Flood Forecast and Warning Center, an operational agency of Bangladesh government.

Interdisciplinary Science Applications to Glacier and Alpine Hazards in Relation to Development and Habitation in the Hindu Kush-Himalaya: SERVIR Science Team Project (ROSES 2011 - SERVIR AST)

Principal Investigator: Jeff Kargel, University of Arizona

ASP Application Area: Disasters

Thematic Service Area: Water Resources and Hydroclimatic Disasters

Description: This project created a satellite image time series of glacier lakes, conducted topographic and hydrological analysis, and performed field studies of glacier lakes for designing a warning system on glacial lake outburst flood. Kargel and his team provided analysis to the UN Development Program on the dangerous rise of Lake Imja in Nepal. Based on this analysis, UNDP provided assistance to the Nepal Army to lower the dam by over 10 feet, substantially reducing the risk from a lake outburst flood.

Building Lasting Capacity for Water Management in Vulnerable Deltas of Indochina (ROSES 2015 - SERVIR AST)

Principal Investigator: Hyongki Lee, University of Houston

ASP Application Area: Water Resources

Thematic Service Area: Water Resources and Hydroclimatic Disasters

Description: This project develops a comprehensive, satellite data-based system that can routinely map, provide early warning of, and enable decision-making on water-related vulnerability issues in low-lying deltas of Indochina.

Supporting satellite-based national land-cover and land-use change monitoring systems in South-East Asian countries (Burma, Cambodia, Laos, Thailand, and Vietnam) (ROSES 2015 - SERVIR AST)

Principal Investigator: Peter Potapov, University of Maryland, College Park

ASP Application Area: Ecological Forecasting

Thematic Service Area: Land Cover and Land Use Change and Ecosystems

Description: This tool employs annual Landsat time-series data to create regionally consistent annual tree canopy cover and height layers at 30m spatial resolution for Southeast Asian Countries. The provided data and data analysis tools are designed to help develop regionally consistent annual forest extent and change maps and implement monitoring results in national and regional planning and management.

Improved Hydrologic Decision Support for the Lower Mekong River Basin through Integrated Remote Sensing and Modeling (ROSES 2015 - SERVIR AST)

Principal Investigator: John Bolten, NASA Goddard Space Flight Center

ASP Application Area: Water Resources

Thematic Service Area: Water Resources and Hydroclimatic Disasters

Description: This project complements and improves ADPC/SERVIR-Mekong hydrological modeling capabilities and access to state-of-the-art Earth observation satellite data to enhance their water resource management decision-making and agricultural monitoring and forecasting capabilities.

Monitoring and Forecasting Drought and Crop Yield for the Lower Mekong Basin (ROSES 2015 - SERVIR AST)

Principal Investigator: Stephanie Granger, NASA Jet Propulsion Laboratory

ASP Application Area: Agriculture

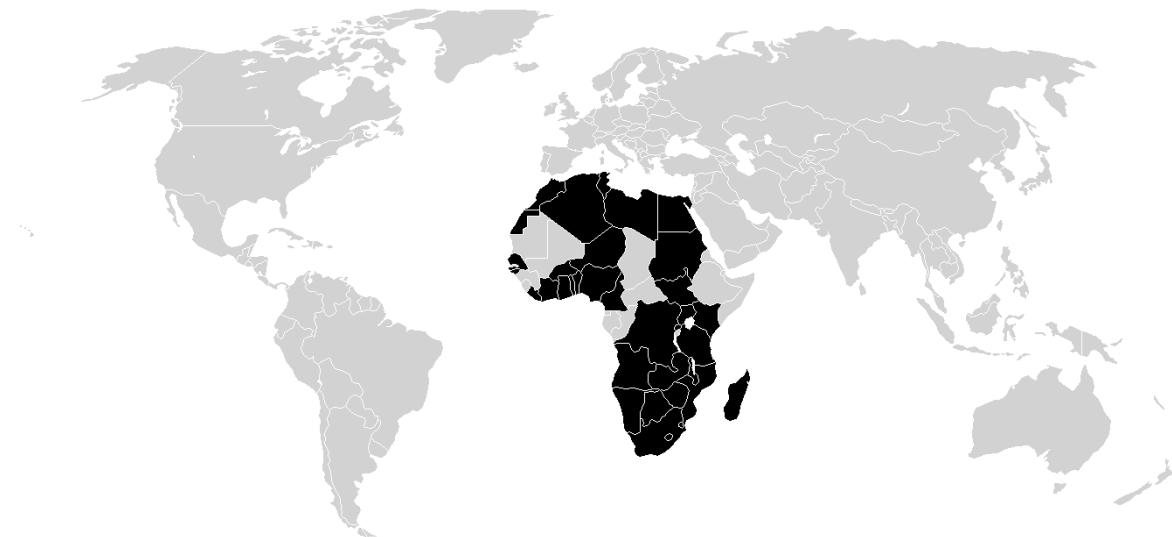
Thematic Service Area: Agriculture and Food Security

Description: This project uses NASA data, local ground observations, and forecasts in a modeling system to provide hydrologic data and drought assessments with associated agricultural yield for the Lower Mekong Basin.

Africa

CBP reached 37 countries in the Africa caucus region through:

- ▶ ARSET – 298 individuals through 9 online trainings
- ▶ DEVELOP – 5 individuals through 6 feasibility studies
- ▶ SERVIR – 209 individuals and 21 multi-year projects and 13 in-person trainings



Black denotes the 37 countries in Africa impacted by CBP

More information for the multi-year projects:

Forecasting and Communicating Water-Related Disasters in Africa (ROSES 2015 - SERVIR AST)

Principal Investigator: Yang Hong, University of Oklahoma, Norman

ASP Application Area: Disasters

Thematic Service Area: Water Resources and Hydroclimatic Disasters

Description: This project uses the EF5 (the Ensemble Framework for Flash Flood Forecasting) hydrologic model to enhance decision-making for water and water-related disasters in Eastern and Southern Africa.

Supporting National Agricultural Monitoring for Food Security (ROSES 2015 - SERVIR AST)

Principal Investigator: Inbal Becker-Reshef, University of Maryland, College Park

ASP Application Area: Agriculture

Thematic Service Area: Agriculture and Food Security

Description: This project builds capacity and develops remote sensing, smart phone, and collaborative internet technologies for the collection, analysis, and dissemination of data on the status of agriculture and crop condition as a basis for decision-making, policy design, and agricultural development interventions in Eastern and Southern Africa.

Enhancing Eastern and Southern Africa Climate Services by Increasing Access to Remote Sensing and Model Datasets (ROSES 2015 - SERVIR AST)

Principal investigator: Shraddhanand Shukla, University of California, Santa Barbara

ASP Application Area: Agriculture, Climate

Thematic Service Area: Agriculture and Food Security

Description: This project enhances SERVIR-Eastern and Southern Africa/RCMRD's access to NASA and Famine Early Warning System Network (FEWS NET) Earth observations, datasets, models, forecasts, and web-

services to support agricultural and water resources decision making by ministries and organizations in the region.

Enabling Local Monitoring of Landscape Change Across Eastern Africa (ROSES 2015 - SERVIR AST)

Principal Investigator: Sean Healey, U.S. Forest Service, Rocky Mountain Research Station

ASP Application Area: Ecological Forecasting

Thematic Service Area: Land Cover and Land Use Change and Ecosystems

Description: This project enables SERVIR-Eastern and Southern Africa/RCMRD to use cloud computing and the Landsat archive to deliver historical and continuously updated 30-meter maps of land cover across Kenya, Malawi, Ethiopia, Zambia, Tanzania, Rwanda, and Uganda.

Development and Implementation of Flood Risk Mapping, Water Bodies Monitoring and Climate Information for Disaster Management and Human Health (ROSES 2011 - SERVIR AST)

Principal Investigator: Pietro Ceccato, International Research Institute for Climate and Society (IRI),

Columbia University

ASP Application Area: Health and Air Quality

Thematic Service Area: Water Resources and Hydroclimatic Disasters

Description: This project has developed the capacity to integrate NASA remotely-sensed products for establishing an improved vector-borne disease risk assessment tool for use by targeted stakeholders. The project team has developed water bodies mapping techniques and held several successful trainings with end users and ministries in East Africa. SERVIR-Eastern and Southern Africa is also looking at operationalizing the water body mapping for uses in rangeland pastureland management.

East Africa Drought and Agricultural Productivity Assessment and Prediction System (ROSES 2011 - SERVIR AST)

Principal Investigator: Stephanie Granger, NASA Jet Propulsion Laboratory

ASP Application Area: Agriculture, Water Resources

Thematic Service Area: Agriculture and Food Security

Description: This project is supporting farming practices in East Africa by helping farmers assess potential end of the season crop yields using crop and hydrologic models, Earth observations, and seasonal forecasts and outlooks. Since its inception, the project has coupled the Variable Infiltration Capacity (VIC) and Decision Support System for Agrotechnology Transfer (DSSAT) models for several crop type modules. The system is installed at SERVIR-Eastern and Southern Africa hub, and several end users in Kenya, Ethiopia, and Zambia are trained on the use of the derived products. The SERVIR hub is developing effective ways to disseminate these useful products.

Forest Carbon Assessment for REDD in the East Africa SERVIR Region (ROSES 2011 - SERVIR AST)

Principal Investigator: Scott Goetz, Woods Hole Research Center

ASP Application Area: Ecological Forecasting

Thematic Service Area: Land Cover and Land Use Change and Ecosystems

Description: This project aims to demonstrate that NASA Earth science products and derived models can assist stakeholders and decision makers with their terrestrial carbon assessment and forest conservation strategies. This project has built significant capacity in carbon accounting at the SERVIR-Eastern and Southern Africa hub.

SERVIR Water Africa-Arizona Team (SWAAT) (ROSES 2011 - SERVIR AST)

Principal Investigator: Juan Valdes, University of Arizona

ASP Application Area: Water Resources

Thematic Service Area: Water Resources and Hydroclimatic Disasters

Description: This project developed hydrologic modeling capabilities to monitor water resources in Africa. The outcome of this effort is provision of near-term streamflow forecasts in three key pilot basins (Mara, Tekeze, and Zambezi) and a quantitative assessment of seasonal outlook on water resources in these basins. Kenyan and Namibian water resources departments have used the derived datasets in making water allocation decisions.

A Long Time-Series Indicator of Agricultural Drought for the Greater Horn of Africa (ROSES 2011 - SERVIR AST)

Principal Investigator: James Verdin, U.S. Geological Survey Sioux Falls/FEWS NET

ASP Application Area: Agriculture

Thematic Service Area: Water Resources and Hydroclimatic Disasters

Description: This project created a long time-series indicator of agricultural drought in the Greater Horn of Africa using remotely sensed observations. Since its inception, this project has generated a 30-year rainfall and drought indicator data sets (1981 to present) using a variety of available satellite data and model products. The data are being used by the SERVIR-Eastern and Southern Africa hub in helping countries in their region with water resources and agriculture analysis.

A West Africa LDAS for Forecasting Extreme Hydrological Events (WALFEHE) (ROSES 2015 - SERVIR AST)

Principal Investigator: Augusto Getirana, NASA Goddard Space Flight Center

ASP Application Area: Climate

Thematic Service Area: Water Resources and Hydroclimatic Disasters

Description: This project provides an improved land data assimilation system (LDAS) for integrated water management in Agriculture, Hydrology and Meteorology (AGRHYMET) Regional Center member nations, with a focus on hydrological modeling to provide meteorological, hydrological, and agricultural drought characterizations and forecasts, and flood modeling and forecasting.

Monitoring and Projecting Environmental Change in Fragmented Tropical Forest Landscapes (ROSES 2015 - SERVIR AST)

Principal Investigator: Michael Wimberly, GISc Center of Excellence, South Dakota State University

ASP Application Area: Ecological Forecasting

Thematic Service Area: Land Cover and Land Use Change and Ecosystems

Description: This project integrates Landsat data and landscape simulation models to map historical forest degradation and project future impacts of climate and land use change on West African forests.

Desertification or "re-greening"? Adaptation lessons learned in coping with late 20th century drought in West Africa (ROSES 2015 - SERVIR AST)

Principal Investigator: Alessandra Giannini, International Research Institute for Climate and Society (IRI), Columbia University

ASP Application Area: Climate

Thematic Service Area: Weather and Climate

Description: This project uses information from Earth observations and model simulations to develop climate information for decision-making in natural resources management, including water and landscapes, to improve agriculture and food security outcomes in West Africa.

Supporting Pastoralist Livelihoods in West Africa Through Remote Sensing of Rangeland Vegetation Structure, Forage Production and Long-Term Trend Analysis (ROSES 2015 - SERVIR AST)

Principal Investigator: Niall Hanan, New Mexico State University

ASP Application Area: Agriculture

Thematic Service Area: Agriculture and Food Security

Description: This project assists SERVIR-West Africa in developing remote sensing based applications relevant to rangeland vegetation structure and forage production in order to improve the wellbeing and resilience of pastoralist and agropastoralist communities in West Africa.

Leveraging CMIP5 and NASA / GMAO Coupled Modeling Capacity for SERVIR East Africa Climate Projections (ROSES 2011 - SERVIR AST)

Principal Investigator: Franklin (Pete) Robertson, NASA Marshall Space Flight Center

ASP Application Area: Climate

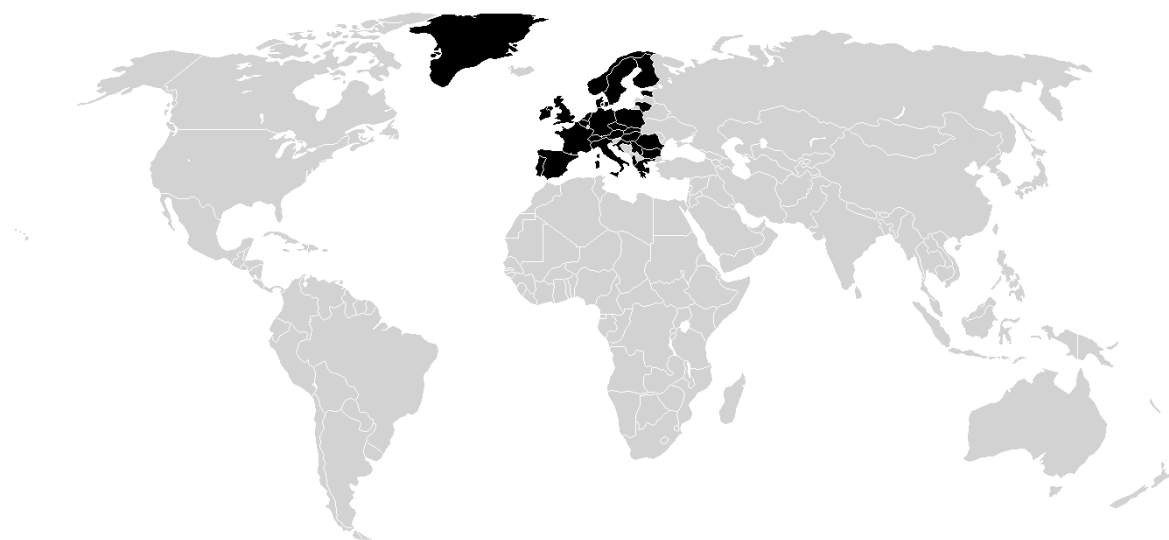
Thematic Service Area: Weather and Climate

Description: This project critically assessed and employed climate model projections of seasonal hydro-meteorological climate variability affecting SERVIR hub regions and developed spatially downscaled scenarios to enable other AST investigators to drive decision support systems on seasonal time horizons. The project's outputs have been used in several other AST projects and hub activities.

Europe

CBP reached 27 countries in the Europe caucus region through:

- ▶ ARSET – 369 individuals through 9 online trainings
- ▶ DEVELOP – 2 individuals and 2 feasibility studies



Black denotes the 27 countries in Europe impacted by CBP

Commonwealth of Independent States (CIS)

CBP reached 7 countries in the CIS caucus region through:

- ▶ ARSET – 29 individuals through 9 online trainings
- ▶ DEVELOP – 2 individuals



Black denotes the 7 countries in Europe impacted by CBP

VII. Program Management

Management Team

Capacity Building is led by Dr. Nancy Searby at NASA Headquarters. In 2016, the Program was supported by Christine Mataya, Sarah Hemmings, Georgina Crepps, and Lauren Childs-Gleason, who served as liaisons between the Elements and NASA Headquarters. Each Element was led by management teams at NASA Centers: ARSET – Dr. Ana Prados, UMD at GSFC; DEVELOP – Michael Ruiz, NASA LaRC; and SERVIR – Dan Irwin, NASA MSFC. The Indigenous Peoples Assessment study was led by Dr. Cindy Schmidt, BAERI at ARC.

Strategic Planning

Capacity Building continues to strengthen through enhancement of programmatic assessment methods and tools. In late March of 2016, CBP management and Element teams gathered in Hampton, Va., to conduct a Strategic Planning Workshop. Participants reviewed the pilot results framework and finalized the set of indicators to collect, enhanced methods of collaboration within the program, strategic partnerships and activities for 2016.

CBP continues its programmatic goal to enhance activities that promote and improve engagement, entrepreneurship, and evaluation.

- **Engagement.** CBP pursues approaches that increase connectivity with current partners, reach out to potential end users, and engage Earth scientists who may be interested and skilled in applications. By improving programmatic understanding of key needs and user preferences, new communities are targeted and engaged.
- **Entrepreneurism.** Through experimentation and adoption of innovative methods for building capacity, CBP implements the Program's strategy to include creative approaches to data access, idea generation, brokering connections, funding of projects, use of social media and community challenges, and reporting of outcomes. This focuses on creative solutions that increase effectiveness and expand the reach of the program.
- **Evaluation.** Monitoring and evaluation through the tracking of indicators across all Elements is performed. This activity includes the refinement of results frameworks for each Element and the program as a whole, as well as the identification and collection of shared indicators across all elements. Improved monitoring increases efficiency and assists with identification of highlights and successes.

Two of the three program Elements, ARSET and SERVIR, held strategic meetings in 2016, while DEVELOP's retreat is scheduled for January 2017. In addition, the Indigenous Peoples Assessment study was completed in 2016 to inform 2017 CBP plans.

ARSET held its third annual retreat the first week of November at GSFC, with all 15 team members in attendance. The team revised its mission and vision, discussed current trainings, and identified key training criteria and new initiatives for 2017. ARSET added six new team members, both trainers and students, to support training in Water Resources, Disasters, and Health & Air Quality, as well as communications and database management. In 2017, ARSET will consider new training approaches through the use of a learning management system.

The 3rd annual SERVIR Joint Working Group (JWG) meeting took place in Washington D.C., in May 2016 among USAID and NASA HQ Earth Science Division leadership and SERVIR SCO leadership. The JWG reviewed Lessons Learned and reaffirmed strategic directions for SERVIR and expansion of the SERVIR network. The JWG discussed SERVIR Hub expansion and the demand from South America, Central Asia, and other emerging/strategic regional priorities. The SERVIR program also hosted the SERVIR Annual Global Exchange (SAGE) October 24-28 in Pokhara, Nepal. The meeting resulted in agreement on the service planning process, which efficiently links the needs from end users in SERVIR regions to product and intervention development and evaluation of intervention efficacy. SAGE was also critical for AST PIs and SERVIR hubs to address integration and co-development of services for the upcoming year.

Program Assessment

At the program level, CBP continues to work towards its five strategic goals, while building a robust network of engagement with other capacity building programs and initiatives. The program collects outcomes through success stories, highlights, ARSET surveys, and DEVELOP

participant surveys. Indicators are used to track intermediate results. Strategic targets are annually assessed, along with ARL and PSI scores to track yearly progress.

Indicator Tracking

A new programmatic performance tracking system was initiated in 2016 through results frameworks that identify unique indicators for each Element, with a refined number of program-wide indicators collected across all Elements. After challenges in collection during a pilot test, an updated timeline for collection has begun on a quarterly system beginning in the 4th quarter of 2016, with a set of shared indicators compiled for CBP as a whole.

2016 4th Quarter Aggregated Indicators:

IR-1: Improved Awareness of – and Access to – Earth observation Data, Products, and Tools	
<i>Sub-IR 1.1: Awareness Increased in New Geographic Regions & Different Sectors</i>	
1.1.1 The Number of States & Countries Reached through CBP Trainings & Projects	38 states; 76 countries
1.1.2 The number of Partners (by type) Reached through Trainings & Projects	Total: 268 – Academic Institution (83); Research Institution (14); Local Government (4); State/Provincial Government (11); Federal/Central Government (98); Intergovernmental Organization (9); Consortium (9); Private Sector (For-Profit) (19); Private Sector (Non-Profit)/Voluntary OR NGO (16); Tribal Entity (1); Miscellaneous/Other (4)
<i>Sub-IR 1.2: Individual & Institution Needs Identified</i>	
1.2.1 The number of front end engagement activities (pre-assessments/needs assessments)	1
<i>Sub-IR 1.3: Access to Data, Products, Tools & Trainings Enhanced</i>	
1.3.1 The number of CBP trainings & projects by ASP National Application Area	Total: 56 – Agriculture (9); Climate (10); Disasters (6); Ecological Forecasting (9); Energy (0); Health & Air Quality (4); Oceans (0); Water Resources (15); Weather (1); Cross-Cutting (1)
1.3.2 The number of CBP products posted online	21
1.3.3 The number NASA Earth observation platforms & sensors utilized in projects & highlighted in trainings	37
IR-2: Strengthened Capacity to Use Earth Observation Data, Products & Tools	
<i>Sub-IR 2.1: Individuals Engaged & Trainings Delivered</i>	
2.1.1 The number of trainings & workshops given or facilitated by CBP Elements	10
2.1.2 The number of individuals engaged in CBP activities	381
<i>Sub-IR 2.2: Tailored Products & Tools Co-developed</i>	
2.2.1 The number of products developed by/with support from CBP	46
<i>Sub-IR 2.3: Increased Number of Organizations Using NASA Earth Observations in Their Decision Making Process</i>	
2.3.1 The number of end-users integrating Earth observations in their decision making process	6
<i>Sub-IR 2.4: Science Policy Exchanges Enhanced</i>	
2.4.1 The number of policy & science conferences attended	20
2.4.2 The number of science policy exchanges involving CBP engagement	0
IR-3: Improved Capacity Building Practices & feedback to Earth Science Community	
<i>Sub-IR 3.1: Best Practices & Lessons Learned Collected & Shared</i>	
3.1.1 The number of best practice documents produced and/or presented by CBP	0 *

3.1.2 The number of outreach events for CBP activities	7
<i>Sub-IR 3.2: Increased Capability to Monitor & Evaluate Impact of CBP Activities and Collect Feedback</i>	
3.2.1 The percent of individuals who completed pre-training/project surveys & project assessments	ARSET (**); DEVELOP (**); SERVIR (**)
3.2.2 The percent of individuals who completed post-training/project surveys & project assessments	ARSET (22%); DEVELOP (89%); SERVIR (**)
3.2.3 The number of projects that achieved yearly ARL goal	**
3.2.4 The annual average PSI score for feasibility projects	**
<i>Sub-IR 3.3: Feedback to Earth Science Community Delivered</i>	
3.3.1 The number of presentations at Science Team Meetings	0
3.3.2 The number of DAAC feedback activities	0

* An ARSET training was conducted highlighting best practices for creating trainings and the CBP has contributed to a CEOS WGCapD best practices document currently in progress.

** To be measured in 2017.

Strategic Targets

Each element addresses strategic goals and contributes to the objectives through specific targets and activities. Targets were identified in 2015 at a strategic planning workshop, then piloted in 2015 and 2016.

ARSET

Activity	Target	2016 Actual
U.S. States Impacted	40	50
Countries Impacted	90	130
Total # of Participants	1,500	3,277
Total # of Organizations	500	1,392
Application Areas Covered	4	7

DEVELOP

Activity	Target	2016 Actual
U.S. States Impacted	35	42
International: Domestic Project Ratio	1:4	~1:4 (27%)
Total # of Participants	250	359
Total # of Partner Organizations	75	125
Total # of Projects	60	77
Application Areas Covered	9 (All)	8

SERVIR

Activity	Target	2016 Actual
Countries Directly Served	38	40

Products Developed	33	38
Total # of PI Leads	27	27
Total # of Participants (Stakeholder Receiving Training)	283	623
Total # of Organizations with Improved Capacity	27	143
USG Science Expertise Connections	5	5

Project Progress Tracking

Capacity Building tracks projects through two measurements: SERVIR AST's long-term projects are tracked using the Application Readiness Level (ARL) scale which begins at 1 (basic research) and continues to a 9 (sustained use of tool); and DEVELOP feasibility projects are tracked using the Project Strength Index (PSI).

ARL Metrics for Multi-Year Projects in 2016:

Metric	ROSES 2011	ROSES 2015*
SERVIR AST ARL Range	6-9	1 - 6
SERVIR AST ARL Mean	7.5	3.0
SERVIR AST ARL Mode	8	3
# of Projects with ARL 1-3:	0	10
# of Projects with ARL 4-6:	1	4
# of Projects with ARL 7-9:	10	0
% of Projects Advanced 1+ ARL in past 12 months	100% (11 of 11)	N/A**

*: Note--ARL information for two of the 16 ROSES-2015 AST projects are still pending

** : ROSES-2015 AST projects, having recently confirmed their ARLs, are still at their start ARLs.

For the 11 AST projects selected through ROSES-2011, the average ARL advanced from 6.4 to 7.6 over the calendar year. As of November 2016, 10 of the 11 projects had reached an ARL of 7 or higher, and 6 had reached 8 or higher. For the 16 AST projects selected through ROSES-2015, initial and goal ARLs have been defined, and begun reporting progress.

DEVELOP continued to track and assess its feasibility projects by means of its PSI. This scale takes into consideration both the scientific merit of the work, as well as the project's applicability to decision making and partner capacity building. In 2016, DEVELOP began a reformulation of the PSI, which measures a project on two spectra: scientific merit and the applicability to decision making and capacity building of the project partners. The PSI tracks the progress of projects across a 5 point scale of 1) Basic Research, 2) Application Concept Complete, 3) Application Demonstration Successful, 4) Application Verified/End User Engaged, and 5) Transition to End User/Decision Enhanced. The new PSI is split into two parts, with one assessment being done after each project term, and a follow-up roughly 4-6 months after the completion of the project. The new system was implemented beginning in the summer 2016 term. For DEVELOP's spring 2016 projects, using the previous PSI metrics, 4 percent of projects ended in Stage 1, 15 percent in Stage 2, 46 percent in Stage 3, and 35 percent in Stage 4. Through Part I of the PSI, the summer projects resulted in 7 percent in Stage 2, 83 percent in Stage 3, and 10 percent in Stage 4. After the Part II follow-up, 63 percent of those projects increased in their final stage, including two projects assessed as Stage 5. For the fall projects, 14 percent were in Stage 2, 76 percent in Stage 3, and 10 percent in Stage 4. The PSI Part II assessments will be conducted in the upcoming months.

Internal Collaborative Activities

The Capacity Building Program integrates and efficiently leverages activities between program Elements. In 2016, the program continued collaboration between the elements in the following ways:

- ARSET team members served as mentors to multiple DEVELOP projects.
- 53 DEVELOPers and 2 people from SERVIR participated in ARSET trainings, with DEVELOPers attending all nine online trainings offered by ARSET.
- DEVELOP and SERVIR continued their collaboration on four international projects that applied NASA Earth observations to regional issues in Africa and Southeast Asia.
- ARSET and DEVELOP collaborated to represent CBP at the 2016 InterAction Forum to increase engagement of NGOs.
- SERVIR and ARSET began planning a collaborative training to be held in 2017 focusing on the Variable Infiltration Capacity (VIC) hydrologic model and bias correction of satellite precipitation data.
- SERVIR began conversations with the Indigenous People initiative to identify synergies and future collaborative activities
- DEVELOP supported the Indigenous Peoples-focused activities by supporting a project hand-off and engagement meeting with the Navajo Nation

VIII. Looking Ahead

In 2017, the Capacity Building Program will continue to address the CBP strategic goals to expand the networks of individuals and institutions to be aware of, able to access, and able to use Earth observations in their decision making through its interagency and international engagements, leveraging engagement of boundary organizations to help increase reach to key end-user groups, engaging with the broader NASA Earth Sciences community, through its three Elements: ARSET, DEVELOP, and SERVIR, and through pilot Indigenous Peoples activities.

ARSET will explore new online training formats, the inclusion of SAR data into trainings, and host trainings on the use of remote sensing and the United Nations Sustainable Development Goals. DEVELOP plans to expand its reach in the U.S. northeast through the establishment of a new node in Boston, Massachusetts, increase its projects' use of socioeconomic data, and pilot a new interactive mapper to visualize the program's impact. SERVIR will begin to implement 16 new AST projects in SERVIR hub regions, increase the internal capacity to process and use SAR imagery, enhance ClimateSERV and AgriSERV through incorporation of additional datasets and user interfaces, and enter into a planning phase for the future SERVIR-Amazonia hub. In 2017, work will begin to address the needs of Indigenous Peoples through pilot activities focused on incorporating traditional ecological knowledge and Earth observation information.

Collectively, the program will use existing and new Earth-observation assets in trainings and projects, furthering the goal to enable sustained use of existing NASA Earth observations and the ability to incorporate new observations and applications as they become available, DEVELOP will continue to conduct feasibility projects using under-utilized assets with potential for applications, ARSET will continue to interact with Early Adopter programs for upcoming missions, and SERVIR will bring the latest research using these assets to SERVIR hubs to enable sustained use.

All CBP elements will contribute to the CBP goal to build Earth sciences community capacity to define end-user needs, collect and share robust feedback, build capacity, and assess impact of capacity building activities through their new webinar series on training best practices. SERVIR's

service planning framework may be shared more broadly as its application matures. As a contribution to CEOS WGCapD, CGMS, and GEO, CBP team members will continue to provide thought leadership and share best practices with the broader community engaged in building capacity to use Earth observations for societal benefit.

To improve feedback of lessons learned through capacity building to the broader Earth science community, CBP will continue to grow a community of practice of Earth observation use capacity building practitioners through science conferences like the American Geophysical Union fall meeting, through relationships with other program managers in Applied Sciences and in Research and Analysis, through participation in DAAC User Working Groups and Science Team meetings, and through broader engagement with the community.

Focused on its five strategic goals, CBP will continue to evolve and strengthen as it further refines methods for tracking progress and impact. Capacity Building management will continue to work with the program element teams to ensure that they have the resources to continue their mission to do great work and to integrate and benefit from each other's work.

IX. Appendix

A. Abbreviations and Acronyms

ADPC: Asian Disaster Preparedness Center	IIRS: Indian Institute of Remote Sensing
AGRYMET: Agriculture, Hydrology and Meteorology Regional Center	IMN: Instituto Meteorológico Nacional
AGU: American Geophysical Union	INETER: Instituto Nicaragüense de Estudios Territoriales
ARC: Ames Research Center	ISRO: Indian Space Research Organization
ARL: Application Readiness Level	IUAPPA: International Union of Air Pollution Prevention and Environmental Protection Associations
ARSET: Applied Remote Sensing Training	IUCN: International Union for Conservation of Nature
ASDC: Atmospheric Science Data Center	IWM: Institute for Water Modeling
ASP: Applied Sciences Program	JPL: Jet Propulsion Laboratory
AST: Applied Sciences Team	JWG: Joint Working Group
BAERI: Bay Area Environmental Research Institute	KMS: Kenya Meteorological Service
CAA: Clean Air Asia	LAADS DAAC: Level-1 and Atmosphere Archive & Distribution System
CBP: Capacity Building Program	LANCE: Land, Atmosphere Near real-time Capability for EOS
CDC: Centers for Disease Control	LaRC: Langley Research center
CEOS: Committee on Earth Observation Satellites	LIS: Land Information Systems
CHIRPS: Climate Hazards Group InfraRed Precipitation with Station	LP DAAC: Land Processes Distributed Active Archive Center
CILSS: Comité permanent Inter-Etats de Lutte contre la Sécheresse dans le Sahel	MaMaSe: Mau Mara Serengeti (Sustainable Water Initiative)
CMAQ: Community Mesoscale Air Quality	MARN: Ministerio de Medio Ambiente y Recursos Naturales
COP: Conference of Parties	MET: Model Evaluation Tool
DAACs: Distributed Active Archive Centers	MOAD: Ministry of Agricultural Development
DSM: Digital Surface Model	MODIS: Moderate Resolution Imaging Spectroradiometer
E&SA: Eastern & Southern Africa	MRC: Mekong River Commission
ET: Evapotranspiration	MSFC: Marshall Space Flight Center
FAO: Food and Agriculture Organization	MWAR LAC: Managing Water Resources in Arid and Semi-Arid Regions of Latin America and the Caribbean
FCCT: Forest Conservation Targeting Tool	NASA: National Aeronautics and Space Administration
FCET: Forest Conservation Evaluation Tool	NDVI: Normalized Difference Vegetation Index
FFWC: Flood Forecasting and Warning Center	NEX-GDDP: NASA Earth Exchange Global Daily Downscaled Projections
FRA: Forest Resources Assessment	NMME: North American Multi-Model Ensemble
GDP: Gross Domestic Product	NOAA: National Oceanic and Atmospheric Administration
GEE: Google Earth Engine	NPS: National Park Service
GEO: Group on Earth Observations	ORNL DAAC: Oak Ridge National Laboratory Distributed Active Archive Center
GES DISC: Goddard Earth Sciences Data and Information Services Center	PCRWR: Pakistan Council of Research in Water Resources
GIS: Geographic Information System	PI: Principal Investigator
GLOFs: Glacial Lake Outburst Floods	PM2.5: Particulate Matter (PM2.5 are fine particles 2.5 micrometers in diameter or smaller)
GPM: Global Precipitation Measurement	PSI: Project Strength Index
GRACE: Gravity Recovery and Climate Experiment	RCCP: Regional Climate Change Program
GRASP: Great Apes Survival Project	
GSFC: Goddard Space Flight Center	
GVF: Green Vegetation Fraction	
HICO: Hyperspectral Imager for the Coastal Ocean	
HKH: Hindu Kush-Himalaya	
IADB: Inter-American Development Bank	
ICIMOD: International Centre for Integrated Mountain Development	
ICPAC: Intergovernmental Authority on Development (IGAD) Climate Predication and Applications Centre	
IDEA: Infusing Satellite Data into Environmental Applications	

RCMRD: Regional Center for Mapping of Resources for Development
 REDD+: Reducing Emissions from Deforestation and Forest Degradation
 RHEAS: Regional Hydrologic Extremes Assessments System
 SAR: Synthetic Aperture Radar
 SCO: Science Coordination Office
 SEI: Stockholm Environment Institute
 SIG: Spatial Informatics Group
 SLEEK: System for Land Based Emissions Estimation in Kenya
 SMAP: Soil Moisture Active Passive (Mission)
 SPLITER: SERVIR Processing of Land Information Toolbox for Earth Resource
 SPoRT: Short-term Prediction Research and Transition Center
 SRTM: Shuttle Radar Topography Mission
 TRMM: Tropical Rainfall Measuring Mission

UEMS: Unified Environmental Modeling System
 UNCCD: United Nations Convention to Combat Desertification
 UNESCO: United Nations Educational, Scientific, and Cultural Organization
 UNFCCC: United Nations Framework Convention on Climate Change
 USDA: United States Department of Agriculture
 USFS: United States Forest Service
 VIC: Variable Infiltration Capacity
 VIIRS: Visible Infrared Imager Radiometer Suite
 VLAB: The Virtual Laboratory
 WFP: World Food Programme
 WGCapD: Working Group for Capacity Building and Data Democracy
 WMO-CGMS: World Meteorological Organization and the Coordination Group for Meteorological Satellites

B. Publications

1. Anderson, E., Griffin, R., and D. Irwin (2016) Implications of different digital elevation models and preprocessing techniques to delineate debris flow inundation hazard zones in El Salvador Natural Hazard Uncertainty Assessment: Modeling and Decision Support (AGU Press), ISBN: 978-1-119-02786-7 (Chapter 11)
2. Blackman, A., L. Goff, and M. Rivera (2016) Does eco-certification stem tropical deforestation? Forest Stewardship Council Certification in Mexico. 17th Annual World Bank Conference on Land and Poverty, Washington, D.C., March 14-18, 2016
3. Childs-Gleason, L., G. Crepps. (2016) Addressing Environmental issues in America's National Parks: A Collaboration Between NASA DEVELOP and the National Park Service. *The Earth Observer*. November - December 2016 Vol. 28, Issue 6, pp. 14-21, 57.
4. Crepps, Georgina. (2016) Assessing the Impacts of Building Capacity in the Use of Earth Observations through the NASA DEVELOP Program. *Earthzine*. April 21, 2016.
5. Crosson, W. et al. (2016) Use of Remotely Sensed Climate and Environmental Information for Air Quality and Public Health Applications. Earth Science Satellite Applications: Current and Future Prospects Hossain, F. (Ed.) ISBN 978-3-319-33436-3, e-ISBN 978-3-319-33438-7 doi: 10.1007/978-3-319-33438-7 pp 173-205
6. Golon, Danielle, Jerrod Lessel, & Tiffani Miller. (2016) Highlights from the NASA DEVELOP National Program Spring 2016 Term. *LP DAAC Data In Action*. June 29, 2016.
7. Hossain, F. (Ed.) (2016) Earth Science Satellite Applications: Current and Future Prospects. ISBN 978-3-319-33436-3, e-ISBN 978-3-319-33438-7 doi: 10.1007/978-3-319-33438-7
8. Hossain, F., et al. (2016) A Global Capacity Building Vision For Societal Applications Of Earth Observing Systems And Data: Key Questions and Recommendations. *Bulletin of American Meteorological Society (BAMS)*, July 2016, DOI:10.1175/BAMS-D-15-00198.1
9. Iqbal, N., F. Hossain, H. Lee, and M.G. Akhtar (2016) Satellite Gravimetric Estimation of Groundwater Storage Variations Over Indus Basin In Pakistan. *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing* Volume:PP, Issue: 99, 1 - 11 DOI 10.1109/JSTARS.2016.2574378
10. Kargel, J.S. et al. (2016) Geomorphic and geologic controls of geohazards induced by Nepal's 2015 Gorkha earthquake. *Science* Vol. 351, Issue 6269., 1-18
11. Miranda, J. J., Corral, L., Blackman, A., Asner, G., & Lima, E. (2016) Effects of Protected Areas on Forest Cover Change and Local Communities: Evidence from the Peruvian Amazon. *World Development* 78: 288-307
12. Nicholas Luchetti, Jessica Sutton, Ethan Wright, Michael Kruk, John Marra. (2016) When El Nino Rages: How Satellite Data Can Help Water-Stressed Islands. *Bulletin of American Meteorological Society*. December 2016. Vol. 97, No. 12, pp. 2249-2255.

13. Roberts, J. B., & Robertson, F. R. (2016) Multivariate Correction and Statistical Disaggregation for Seasonal Multi-Model Ensemble Forecast Applications. American Meteorological Society (AMS) 28th Conference on Climate Variability and Change, New Orleans, La., 13 January, 2016. 7B.5
14. Schumann, G., D. Kirschbaum, E. Anderson, and K. Rashid (2016) Role of Earth Observation Data in Disaster Response and Recovery: From Science to Capacity Building. Earth Science Satellite Applications: Current and Future Prospects Hossain, F. (Ed.) ISBN 978-3-319-33436-3, e-ISBN 978-3-319-33438-7 doi: 10.1007/978-3-319-33438-7_5 pp 119-146
15. Shrestha, A. B.; Bajracharya, S. R.; Kargel, J. S.; Khanal, N. R. (2016) The Impact of Nepal's 2015 Gorkha Earthquake-Induced Geohazards. ICIMOD Research Report 2016/1, ISBN 978 92 9115 386 2 e-ISBN 978 92 9115 387 9 (2016) 48pp
16. Shukla S., Roberts, J., Hoell A., Funk C., Robertson F. and Kirtmann, B. (2016) Assessing North American Multimodel Ensemble (NMME) Seasonal Forecasts. *Climate Dynamics*. 1-17, doi:10.1007/s00382-016-3296-z, ISSN: 0930-7575 (Print) 1432-0894 (Online),
17. Sikder, S. et al. (2016) Are General Circulation Models Ready for Operational Streamflow Forecasting for Water Management in the Ganges and Brahmaputra River Basins? *Journal of Hydrometeorology* Vol 17, Issue 1: 195-210 (January 2016)
18. Sinclair, Leigh, Padraic Conner, Tyler Finley, & Jeanné le Roux. (2016) DEVELOP Project Uses NASA Data to Assess Landslide Characteristics in Rwanda and Uganda. *The Earth Observer*. February 2016.
19. Stampoulis D. et al. (2016) Assessing the hydrologic vulnerability and adaptive capacity at regional scales using microwave remote sensing. *Remote Sensing of Environment*, Volume 184, October 2016, Pages 58–72
20. Tang, G. et al. (2016) Statistical and Hydrological Comparisons between TRMM and GPM Level-3 Products over a Midlatitude Basin: Is Day-1 IMERG a Good Successor for TMPA 3B42V7? *Journal of Hydrometeorology*, 17(1), 121-137.
21. Valdés-Pineda, R., Demaría, E. M. C., Valdés, J. B., Wi, S., and Serrat-Capdevilla, A. (2016) Bias correction of daily satellite-based rainfall estimates for hydrologic forecasting in the Upper Zambezi, Africa. *Hydrology and Earth System Sciences*, doi:10.5194/hess-2016-473, 2016.
22. Voigt, S., et al. (2016) Global trends in satellite-based emergency mapping. *Science*, Vol. 353 (Issue 6296), pp 247–252, doi:10.1126/science.aad8728
23. Wright, Ethan E., Jessica R. P. Sutton, Nicholas T. Luchetti, Michael C. Kruk, & John J. Marra. (2016) *Closing the Pacific Rainfall Data Void*. EOS. July 7, 2016.

C. Earth Observation Assets Employed by CBP

Altika	IKONOS	NOAA-17 AVHRR
Aqua AIRS	ISS ECOSTRESS (simulated)	NOAA-18 AVHRR
Aqua AMSR-E	ISS HICO	NOAA-19 AVHRR
Aqua MODIS	Jason-2	PlanetScope Constellation
Aura MLS	Landsat 4 TM	QuickBird-2
Aura OMI	Landsat 5 TM	Radarsat-2
AVIRIS	Landsat 7 ETM+	RapidEye Constellation
CALIPSO CALIOP	Landsat 8 OLI	SAC-D Aquarius
DMSP-13 SSM/I	Landsat 8 TIRS	Sentinel-2 MSI
DMSP-14 SSM/I	MeteoSat SEVIRI	SMAP L-Band Radiometer
DMSP-15 SSM/I	NASA Gulfstream III UAVSAR	SMOS MIRAS
EO-1 ALI	NASA King Air B200 AirSWOT	SRTM
EO-1 Hyperion	NOAA-7 AVHRR	Suomi NPP VIIRS
GeoEye 1	NOAA-9 AVHRR	TEMPO
GeoEye 2	NOAA-11 AVHRR	Terra ASTER
Global Navigation System	NOAA-14 AMSU-B	Terra MISR
Satellites	NOAA-14 AVHRR	Terra MODIS
GOES	NOAA-15 AMSU-B	Terra MOPITT
GOES-PRWEB	NOAA-15 AVHRR	TRMM PR
GPM DPR	NOAA-16 AMSU-B	TRMM TMI
GPM GMI	NOAA-16 AVHRR	WorldView-2
GRACE	NOAA-17 AMSU-B	WorldView-3

D. ARSET 2016 Trainings: Instruments, Web Tools, Missions, and Satellites Covered

Advanced Rapid Imaging and Analysis (ARIA)
Aeronet
Aerostat/Multi-sensor Aerosol Products Sampling System (MAPPS)
AIRS
Atmospheric Land Exchange (ALEXI)
Aqua
Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER)
Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO)
Carbon Mapper
Centers for Disease Control National Environmental Public Health Tracking Network
Consultative Group for International Agricultural Research (CGIAR)
CORal Reef Airborne Laboratory (CORAL)
Dartmouth Flood
Dual Precipitation Radar (DPR)
EarthEnv
Earth Explorer
Earth Observatory
Earthdata Search
EASTWeb
Extreme Rainfall Detection System (ERDS)
Enhanced Thematic Mapper Plus (ETM+)
Evaluation (E-Decider)
Evaporative Stress Index (ESI)
Firecast
Fire Information for Resource Management Systems (FIRMS)
Geodetic Data Exploration (GEOGateway)
Goddard Earth Observing System Model, Version 5 (GEOS-5)
Global Flood Mapping System (GFMS)
Global Inventory Modeling and Mapping Studies (GIMMS)
MODIS
Giovanni-4
Global Land Data Assimilation Systems (GLDAS)
Global Agricultural Monitoring (GLAM)
Global Data Explorer (GDEx)
Global Forest Watch
Global Land Cover Facility (GLCF)
Global Landslide Catalog
Global Learning and Observations to Benefit the Environment (GLOBE)
Global Navigation System Satellites (GNSS)
Global Visualization Viewer (GloVIS)
Google Earth Engine Evapotranspiration Flux (EEFlux)
Geostationary Operational Environmental Satellite (GOES)
GOES Evapotranspiration and Drought (GET-D)
Global Precipitation Measurement (GPM)
Gravity Recovery and Climate Experiment (GRACE)
Himawari 8
Hyperspectral Imager for the Coastal Ocean (HICO)
Infusing Satellite Data into Environmental Applications (IDEA)

Integrated Multisatellite Retrievals for GPM (IMERG)
International Charter
International Space Station
Level-1 and Atmosphere Archive and Distribution System
Web Interface (LAADSweb)
LANCE-MODIS
Land Ecosystem Disturbance Adaptive Processing System (LEDAPS)
Landsat
Map of Life
MERRA
METRIC
Mirador
MISR
MODIS
MODIS Active Fire and Burned Area Product
MODIS NRT Global Flood Mapping
MODSCAG
MOPITT
MRTWeb
The National Map (Digital Elevation Data)
National Snow & Ice Data Center
North American Land Data Assimilation Systems (NLDAS)
NOAA CoastWatch
NOAA Coral Reef Watch
NOAA Harmful Algal Blooms Forecasting
NOAA Hazard Mapping System (HMS)
NOAA/NESDIS Volcanic Alert System
NOAA Whale Watch
NPP
OceanColor Web
OLI
OMI
Plankton, Aerosols, Clouds, ocean Ecosystems (PACE)
PPS/STORM
Precipitation Radar (PR)
RECOVER
Reverb/ECHO
Roffer's Ocean Fishing Forecasting Service
SAR
SeaDAS
SERVIR
Short-Term Prediction Research and Transition (SPoRT)
SMAP
Snow Data System Portal
SRTM
TEMPO
Terra
Tagging of Pelagic Predators (TOPP)
TRMM
VIIRS
VIIRS Active Fire Mapper
Web-Enabled Landsat Data (WELD)
Worldview

E. Organizations Engaged

In 2016, CBP engaged 1,684 organizations through trainings, feasibility studies and multi-year projects. Below you can see organizations classified by sectors:

